

DOE/ER/62312

CONSTRUCTION OF BENDING MAGNET BEAMLINE AT THE APS FOR
ENVIRONMENTAL STUDIES

FINAL REPORT
09/09/1996 – 09/14/1999

E. A. Stern

RECEIVED
JUL 17 2000
OSTI

September 1999

Work Performed Under Contract No. DE-FG07-96ER62312

Prepared for the
U.S. Department of Energy
Assistant Secretary for
Energy Research
Washington, DC

Prepared by
University of Washington
Seattle, WA

62312
Final Report: DOE# DE-FG0796ER62312; ID#54800

Construction of Bending Magnet Beamline at the APS for Environmental Studies

Lead PI: Edward A. Stern, Dept. of Physics, Box 351560, University of Washington, Seattle Washington. Phone #: 206-543-2023; e-mail: stern@phys.washington.edu. Half of postdoc and half of grad. student involved.

DOE problems: Spatial distribution and speciation of toxic and radioactive pollutants.

Research Objective

Design and construction of a bending magnet beamline at the Advanced Photon Source (APS) by the Pacific Northwest Consortium-Collaborative Access Team (PNC-CAT). The beamline will be optimized for x-ray absorption spectroscopy (XAS) studies with a major focus on environmental issues. The beamline will share the experimental facilities under development at the neighboring undulator based insertion device beamline. It will utilize these facilities for XAS of both bulk and surface samples, with spatial and elemental imaging, on toxic and radioactive samples. It will help meet the rapidly growing need for the application of these techniques to environmental problems.

Research Progress and implications

This report summarizes work accomplished to beginning of April, about 1/2 year after the end of the grant period. The original scope of the project was to build a basic bending magnet beamline. This would have housed the optics and experiments in a single radiation enclosure. In Feb. 1997 we obtained additional funding from DOE-BES for the PNC-CAT activities. This funding runs through Jan. 2002, and has allowed us to expand the scope of the original proposed bending magnet beamline. Additional items added to the project include a full sized experimental enclosure separate from the first optical enclosure (FOE), a white beam vertically collimating/focusing mirror providing improved flux and focusing, and enhanced experimental capabilities. We would like to acknowledge the importance of the initial EMSP funding in jumpstarting our bending magnet construction project, and paving the way for obtaining additional funding.

The basic beamline is now complete, and monochromatic beam has been obtained in the final experimental enclosure. The monochromator is based on a well-tested design used on our insertion device beamline, and is performing very well. The figure shows an example of the EXAFS for a Mo foil. The excellent signal to noise allowed us to reach $k=20 \text{ \AA}^{-1}$ in the spectrum. It is expected that a large fraction of the beamtime will be used for similar EXAFS experiments.

A variety of imaging optics have been developed for our insertion device beamline. These include Kirkpatrick-Baez (K-B) mirrors, tapered capillary concentrating optics, and a set up for x-ray tomography. The tomography experiment is well suited to the bending magnet beamline, which provides a larger, more uniform beam. In addition, on the undulator source the experimental efficiency is low. The detector readout time

significantly exceeds typical x-ray exposure times. On the bending magnet, the exposure and readout times are better matched. The K-B and capillary focusing optics will work less efficiently on the lower brilliance bending magnet source, but should still provide useful microbeams with fluxes exceeding 10^7 photons/sec/ μm^2 .

Other capabilities will also be shared with the undulator stations. Currently under development is a Kappa geometry diffractometer. This will provide full diffraction capabilities, including the possibility for diffraction anomalous fine structure (DAFS) measurements. A full range of EXAFS sample environments will be available including a closed cycle refrigerator capable of 15K. Finally, a surface science/MBE chamber, developed for the undulator line, can also be deployed on the bending magnet line. It has capabilities for MBE film growth and characterization, and can be used for surface XAFS, x-ray reflectivity and standing wave measurements.

Planned activities

The beamline has begun commissioning and will soon begin full operations with scheduled experiments. On the undulator beamline, about half of the experiments are related to environmental problems. We expect a similar or greater fraction on the bending magnet line. The personnel required for operating the beamline will continue to be funded from our BES funding for approximately two more years. However, operations past this point will require additional funding. In light of the strong environmental usage planned, we hope that part of this funding can be obtained from environmental programs.

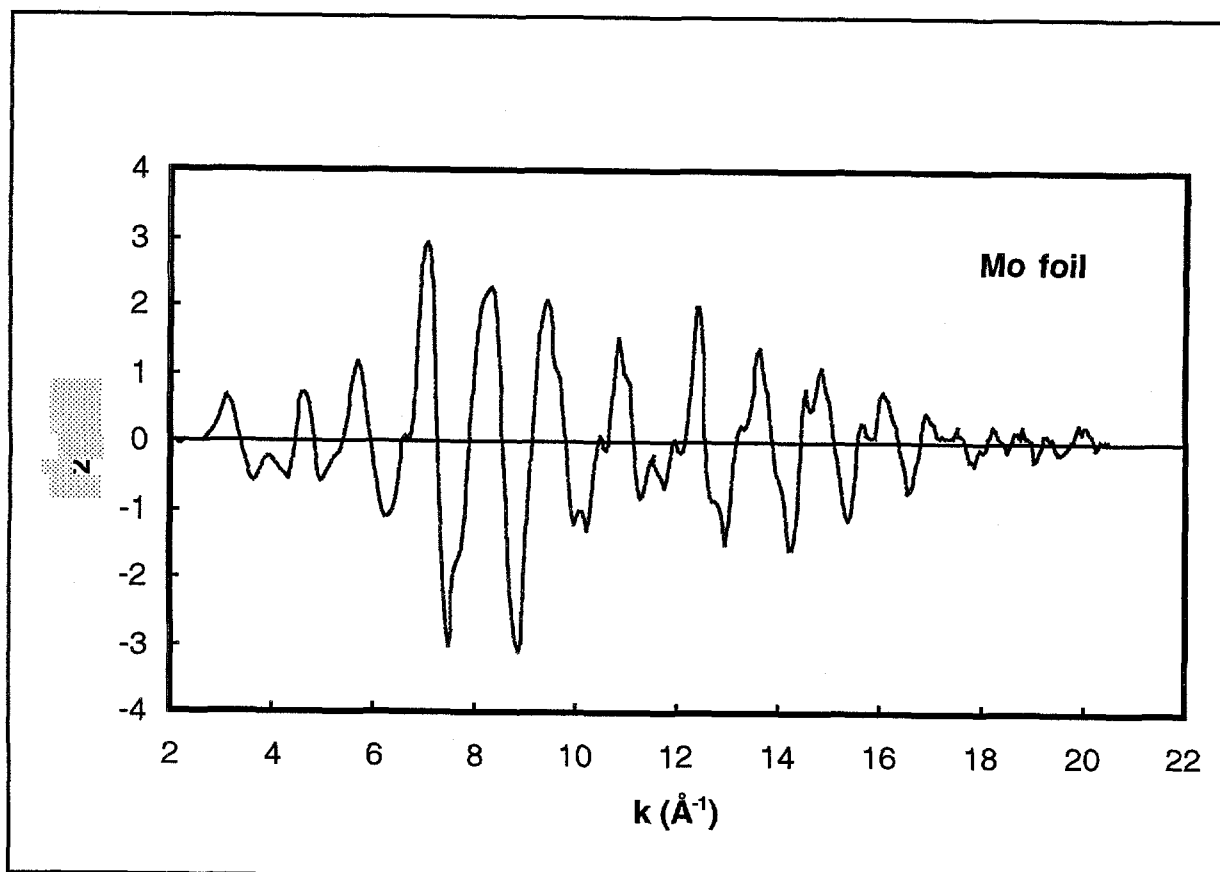
Although the EMSP project has ended, the line will continue to be upgraded under our BES funding. The major planned additions are a sagittal focusing crystal to collect up to 3 mrad of the horizontal fan of radiation, and a focusing/collimating white beam mirror. The crystal will concentrate the horizontal fan of radiation at least 100 times, while the mirror will improve the monochromator throughput by 2-5 times, depending on the operating energy.

Information access

Since this is a construction project, it has not resulted in many publications. A paper that summarizes the PNC-CAT capabilities including the bending magnet line, is:

S. M. Heald, D. L. Brewster, E. A. Stern, K. H. Kim, F. C. Brown, D. T. Jiang, E. D. Crozier, and R. A. Gordon, "XAFS and micro-XAFS at the PNC-CAT beamlines", J. Syn. Rad. 6, 347 (1999).

The APS also maintains a web site (<http://www.aps.anl.gov/xfd/communicator/user2000/reports.html>) containing user activity reports that summarize our experimental activities. Currently these pertain only to the undulator beamline, but they give a flavor of the types of projects that will be carried out on the bending magnet line.



$\chi(k)$ obtained from a Mo foil. The excellent spectra extending to 20\AA^{-1} indicates the good signal to noise of the beamline.